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(21) International Application Number: PCT/US95/13919 (22) International Filing Date: 23 October 1995 (23.10.95) (30) Priority Data: 08/342,326 18 November 1994 (18.11.94) US (71) Applicant: ADVANCED MICRO DEVICES, INC. [US/US]; One AMD Place, Mail Stop 68, Sunnyvale, CA 94088-3453 (US). (72) Inventors: AVANZINO, Steven, C.; 7504 Barnhart Place, Cupertino, CA 95014 (US). WOO, Christy, Mei-Chu; 3590 Rollingside Drive, San Jose, CA 95148 (US). SCHONAUER, Diana, M.; 1136 Brace Avenue, San Jose, CA 95125 (US). BURKE, Peter, Austin; 10926 Jollyville Road #1507, Austin, TX 78759 (US). (74) Agent: RODDY, Richard, J.; Advanced Micro Devices, Inc., One AMD Place, Mail Stop 68, Sunnyvale, CA 94088-3453 (US).		(81) Designated States: JP, KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: METHOD OF MAKING A CHEMICAL-MECHANICAL POLISHING SLURRY AND THE POLISHING SLURRY (57) Abstract A tungsten chemical-mechanical polishing slurry formulated from small median diameter abrasive particles having a very tight diameter variation and by thoroughly premixing the abrasive with a surfactant suspension agent before combining the oxidizer.		

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METHOD OF MAKING A CHEMICAL-MECHANICAL POLISHING SLURRY AND THE POLISHING SLURRY

5 FIELD OF THE INVENTION

A polishing slurry composition and its method of making for planarization of silicon semiconductor wafers by mechanical polishing of the wafer. More particularly, a composition for polishing a wafer having tungsten lines and vias through silicon dioxide dielectric layers where the slurry has a high removal rate selectivity for the tungsten in relation to the silicon dioxide removal rate.

BACKGROUND OF THE INVENTION

Integrated circuit complexity has continued to evolve placing increasingly more demanding specifications on the processes used in their manufacture. As the requirement for increasing the density of active devices on an individual chip has escalated, the requirement for greater flatness, over long distance and short distance, on the surfaces, top and bottom, of the wafer has also evolved. A flat surface is desirable for several reasons. Flatness is a requirement for cooperation with the optical focusing characteristics of optical stepper devices. As the optical lens requirements for increased resolution has increased, the depth of field of the lens has decreased. Also, attachment of the interconnection metallization to their underlayer is improved if the metal is not required to pass over abrupt underlying steps. In addition, flatness improves ability to fill via holes and lines through apertures in the dielectric.

Various processes have been used for planarization. One such process known as chemical-mechanical polishing (CMP) is presently being used in the most demanding applications. CMP enhances the removal of surface material over large distances and short distances by simultaneously abrading the surface while a chemical etchant

selectively attacks the surface.

It is known from the prior CMP efforts that for a particular CMP slurry to be successful it must exhibit significantly different etch removal rates for at least two different materials on the wafer surface. This is called selectivity and is normally
5 shown as a different etch rate for the metal vis-a-vis the interlayer dielectric.

CMP is becoming a preferred method of planarizing tungsten interconnects, vias and contacts. With proper process parameters, CMP tungsten processing has shown significantly improved process windows and defect levels over standard tungsten dry etch-back processing. One significant advantage of CMP tungsten
10 processing is that it has a highly selective polish rate for tungsten as compared to the dielectric. This selectivity allows for over-polishing while still achieving a flat tungsten stud. When overetching using etch-back technology, the contact or via becomes further recessed which creates a serious disadvantage since overetching is frequently required to remove defects. The advantage of CMP, however, can be offset by the
15 creation of significant levels of defects during polishing, such as scratches. Accordingly, the success of tungsten CMP processing performance is linked to improvements in selectivity and defect control.

For various reasons, prior CMP slurries have not been as effective as needed. Most significantly, deep or wide scratch defects of the underlying surface by the
20 abrasive have caused problems. Also, since a large volume of CMP slurry is required, the development of a low-cost chemical composition is essential.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a practical tungsten CMP slurry having excellent selectivity which enables planarization of a silicon integrated circuit

wafer with a low-defect count and excellent uniformity. These objects are achieved by formulating the slurry from abrasive particles having a sufficiently small median diameter and a very tight diameter variation and by thoroughly premixing the abrasive particles with a surfactant suspension agent before combining the oxidizer.

5 A feature of this invention is that it provides a stable polish rate over a wide range of solid slurry content so that the process is more easily controlled.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plot of W removal rate for various wt% alumina in slurry with a fixed oxidizer percentage $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O} = 5 \text{ wt\%}$.

10 FIG. 2 is a normalized plot of removal rate for various wt% of $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ for a fixed abrasive percentage $\text{Al}_2\text{O}_3 = 2.8 \text{ wt\%}$.

FIG. 3 is a chart depicting the average total defect count for slurries made by different mixing sequences.

15 FIG. 4 is a chart depicting the oxide removal rate and tungsten selectivity for different slurry batches.

FIG. 5 is chart of tungsten removal rate and uniformity for different ferric salt oxidizers.

FIG. 6 is a graph of the general shape of the change in defect count as a function of aging for the slurry of this invention.

20 DETAILED DESCRIPTION OF THE INVENTION

Commercially available CMP equipment and slurry materials are currently available for planarization of integrated circuits with tungsten (W) vias through silicon dioxide dielectric layers. These commercial slurry materials each exhibit problems such as high scratch counts, high material cost, rapid settling and poor tungsten selectivity.

We have developed a slurry and a method for making the slurry which substantially addresses and reduces these problems.

Our slurry comprises abrasive particles of a selected diameter, a ferric salt oxidizer and a suspension agent. We have also discovered that it is beneficial to follow
5 an order of adding and of mixing the slurry components for optimum results. The suspension agent should be mixed thoroughly with the abrasive particle aqueous concentrate before adding diluted oxidizer up to the final volume.

We have also discovered a previously unobserved effect. Specifically, we find that the planarization results can be still further improved if the completely mixed
10 slurry is allowed to age for one day or more before being used in that scratch count is still further diminished. While one day of aging improves the scratch results, significant further improvement is obtained with longer aging of more than three days and preferably more than five days.

The abrasive particles can be any of the commonly used abrasives such as
15 alumina (Al_2O_3), silicon carbide (SiC), Ceria (CeO_2), silicon nitride (Si_3N_4) and silicon dioxide (SiO_2). However, we have discovered that a small particle median diameter shows advantages and is preferred and that the distribution from the preferred diameter median should preferably be very tight in order to obtain reduced scratch count. The median diameter of the prior art slurry particles are 0.400 microns, but for our slurry
20 we prefer a median particle size of less than 0.4 microns, preferably 0.220 microns. The preferred distribution of particle size is much tighter than in the prior art also. Our preferred distribution is a one sigma deviation of 0.050 microns or less. We have determined through experimentation that both of these dimensions are important to achieve low incidence of scratching. Using standard optical measurement equipment,

generally, the particle sizes used in prior CMP slurries were in the range of 0.4 to 0.7 micron diameter or larger with little attention to the tightness of the distribution.

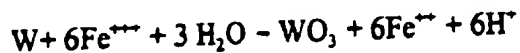
The preferred oxidizer is a ferric salt, selected from the group consisting of $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$, $\text{Fe}_2(\text{SO}_4)_3 \cdot 5\text{H}_2\text{O}$, and $\text{FeNH}_4(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$.

5 The suspension agent is preferably an aqueous based surfactant to improve the colloidal behavior of the abrasive particles in the H_2O system. For the purposes of this invention a commercially available aqueous mixture of propyleneglycol and methylparaben was used as the suspension agent. The suspension agent can also be formulated from the following classes:

- 10 1) glycols such as ethylene glycol, propylene glycol and glycerol;
- 2) polyethers such as polyethylene glycol;
- 3) aliphatic polyethers;
- 4) alkyl sulfates;
- 5) alkoxylated alkyphenols.

15 We believe that CMP of tungsten films takes place by (1) a chemical oxidation of the tungsten surface with a suitable oxidizing agent in an aqueous solution, (2) followed by mechanical abrasion of the more brittle metal oxide which had formed on the surface by the solid abrasive particles present in the aqueous suspension. Both the oxidation and abrasion continue simultaneously and continuously. The reaction for

20 oxidation of tungsten by the ferric ion is



and occurs in an acid solution.

The oxidizer component has other members of the class. Representative members of the class include suitable Fe (III) compounds, such as the following:

Ferric chloride hexahydrate, $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$

Ferric sulfate pentahydrate, $\text{Fe}_2(\text{SO}_4)_3 \cdot 5\text{H}_2\text{O}$

and Ferric ammonium sulfate dodecahydrate, $\text{FeNH}_4(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$

Experiment 1

5 A pair of CMP experiments (Experiment 1 and Experiment 2) as set forth
below were performed to determine the relationship between the percentage of alumina
solid content and percentage of ferric nitrate content in a slurry and the tungsten
removal rate. No surfactant was employed in Experiment 1. In this experiment, the
oxidizer was ferric nitrate $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, which was held constant at 5 weight
10 percent (5 wt%). The results of various percentages of abrasion particles of Alumina
are plotted against the tungsten removal rate in FIG. 1. The experimental procedure
and equipment for Experiment 1 were as follows:

Equipment: Strasbaugh model 6DS-SP polisher.

Wafer carrier: Standard design.

15 Polish Pad: Industry standard.

Test Monitor: Pre-measured blanket tungsten films on Ti/TiN barriers
over plasma TEOS oxide to monitor W removal rate and
within wafer non-uniformity.

Dummy Wafers: Tungsten Dummy wafers identical to test monitors
20 described above, except for the W thickness pre-
measurement. Oxide dummy wafers coated with 2500 Å
oxide.

Metrology tool: Prometrix RS-55. Pre and post polish measurements taken on 49 sites across each wafer with 9mm edge exclusion.

Slurry agitation: Constant agitation during testing.

5 PROCESS PARAMETERS

Burn in: New polish pads are burned in with 2 cycles of 120 seconds polish time/cycle using oxide dummy wafers.

Process Cycle: variable time, 5 psi, 25 rpm carrier, 100 rpm table, 150 ml/min slurry flow.

10 Loading Sequence: For each of seven slurry mixture test compositions selected, perform polish test on 8 tungsten dummy wafers for 220 sec and 4 tungsten Test Monitor wafers for 60 seconds.

15 Test Compositions: Al_2O_3 -- 1 wt%, 2 wt%, 3 wt%, 4 wt%, 5 wt%, 6 wt% and 7 wt%. The $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ is fixed at 5 wt% for all slurries used in Experiment 1.

20 This experiment, as shown in FIG. 1, has a nearly constant W removal rate of $4500\text{\AA}/\text{min}$ — $4900\text{\AA}/\text{min}$ from 2-6 wt% of abrasion particles of Al_2O_3 . Below 2 wt% the removal rate is substantially reduced. In the flat region, the removal rate is essentially independent of the alumina concentration. This suggests that the removal rate depends more on the oxidation rate of the elemental tungsten near the surface and that at these wt% of particles the tungsten oxide is being removed about as fast as its being formed. It is not understood why the curve shows a removal rate drop-off at the percentages above 6 wt%.

The prior CMP tungsten polishing publications teach that the polishing rate is linearly proportional to the concentration of the alumina particles in the concentration range of 3 to 7 wt. percent. However, our experiment shows that the lower concentration can sustain the high polishing rate if the alumina particle is appropriately sized and has the proper size distribution. It appears that certain particle sizes contribute more to polishing. Larger particles when mixed with smaller particles may hinder the polishing performance of the smaller particles by maintaining too large a distance between the wafer and the polishing pad.

Experiment 2

For Experiment 2, the same experimental procedure and equipment were used as set forth in Experiment 1 except that the Test Points for this experiment held the alumina at 2.8 wt% and used six points of different weight percent of ferric nitrate, i.e., 3 wt%, 4 wt%, 5 wt%, 6 wt%, 7 wt% and 9 wt%.

FIG. 2 for Experiment 2 shows the results of W removal rate plotted normalized against removal rate for 5 wt% $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$. The results show a strong W removal rate dependence on concentration of Fe^{3+} between 3 wt% to 5 wt% ferric nitrate. At increased Fe^{3+} concentration, i.e., 5 wt% to 9 wt%, the removal rate is nearly constant for a fixed 2.8 wt% alumina concentration.

This behavior suggests that below 5 wt% ferric nitrate concentration that the polish rate is controlled by the chemical oxidation rate of the freshly exposed W surface undergoing continuous abrasion by Al_2O_3 particles. Above 5 wt% ferric nitrate, the increased Fe^{3+} concentration does not lead to a higher polish rate, which suggests that surface WO_x abrasion rate becomes the rate limiting mechanism.

Experiment 3

Addition of a surfactant not only improved the colloidal suspension time but the surfactant also had an unexpected, very significant effect on the defect scratch count level. The instrumentation counted all scratches of 0.3 microns and above. The surfactant also unexpectedly affected the W selectivity. For Experiment 3 the surfactant used was a commercially available aqueous mixture of propylene glycol and methyl paraben from Universal Photonics Inc., sold under trade name EVERFLO. The order of mixing the slurry components also had an unexpected effect on the results.

A. In Experiment 3, three different 2.5 gallon slurry batches were prepared, each batch having exactly identical ingredient ratios but were combined in a different sequence or manner of adding in the suspension agent:

Batch A: Surfactant was added to container holding alumina and ferric nitrate, previously diluted to near the final volume.

Batch B: Surfactant was added to alumina concentrate. After brief stirring to homogenize the mixture, diluted ferric nitrate was added up to the final volume.

Batch C: Surfactant added to alumina concentrate and mixed by a magnetically driven stirrer for 2 hours, then the diluted oxidizer, ferric nitride, was added to make up the final batch volume.

B. Slurry Composition

Al_2O_3 concentrate @ 14 wt% Al_2O_3 solids: 20% of total slurry volume or Al_2O_3 solids at 2.8 wt% of total slurry weight.

Surfactant: 15% of total slurry volume

Ferric nitrate: 5 wt% of total slurry weight

D.I. water: 65% of total slurry volume

C. Equipment

Defect measurement: ESTEK, model 8500

Oxide removal and non-uniformity: Prometrix SM200

5 Tungsten removal and wafer non-uniformity: Prometrix RS55

Polisher: Strasbaugh 6DS-SP

Pads: Industry standard

D. Procedure

10 Polishing in Strasbaugh carried out at 5 psi spindle down force,
25 rpm spindle rotation, 100 rpm table rotation.

15 A polishing pad was wet-idled overnight. The pad was pre-soaked with slurry for 2 min. Dummies with ≈ 3000 angstroms of tungsten film were polished for 120 seconds, a total of two cycles for pad burn in. Next, two rate monitors with $\approx 8000\text{\AA}$ of tungsten were polished for 60 seconds in one cycle. Then, two oxide-layered wafers were polished for 60 seconds to determine oxide removal rate. Lastly, two additional oxide wafers were polished for 10 seconds at 5 psi and 30 seconds at 2 psi for defect evaluation. Both oxide rate and defect monitor wafers had approximately 2500\AA PETOS. The polish pad was
20 rinsed with DI water thoroughly between different slurry batches.

FIG. 3 shows that when performing CMP using no surfactant that approximately a total of 2000 defects of 0.3 microns or above are counted. For Batch A, where surfactant was added after diluting the abrasive and $\text{Fe}(\text{NO}_3)_3$ to near final volume, the data shows that the defects dropped only slightly to approximately 1800.

A dramatic decrease in scratching to 400 counts is obtained with Batch B where surfactant is added before the dilution and oxidizer with only minimal mixing. The result with Batch C employing a thorough pre-mixing of the abrasive particles with the surfactant before dilution and oxidizer added was seen to reduce the defect count to less than 200. It is believed that the thorough mixing of the surfactant prior to addition of the oxidizer allows the suspension agent to engage and completely coat each alumina particle by nature of the organic surfactant molecules making the particle surface non-polar. It is believed that this precludes the particle from acquiring a charge from the oxidizer, thereby preventing agglomeration. Accordingly, when the mechanical action of the particles are abraded across the W surface, the slurry particles remain smaller and cause less gouging. As seen in FIG. 4, the oxide removal rate (Å/min) is also significantly different for each batch resulting in a very different selectivity which increases from 140:1 to over 400:1 depending on the mixing sequence.

The prior art teaches that tungsten to TEOS polish rate selectivity for CMP is less than 180, see D. Scherber and M. Neville, Chemical and Mechanical Aspects of Consumables Used in CMP, Semicon Southwest Proceedings, p. 36-60 (1994). Further, the known art teaches that high tungsten/TEOS selectivity requires reduced tungsten polish removal rate. As indicated above, our invention teaches that both of these limitations can be avoided.

Experiment 4

For Experiment 4, slurries were made using the same process as described for making Batch C in Experiment 3 for several ferric (Fe^{3+}) salts and the tungsten polish rates and uniformity were measured.

The standard Strasbaugh W-polish configuration of Experiment 1 was employed. Each new slurry, after thorough rinsing, was used to saturate the polishing pad and two burn-in wafers were polished followed by two tungsten test wafers. The results were as plotted in FIG. 5. It is clear that each of the four ferric salts can be
5 successfully used to formulate the W polishing slurry. The ferric chloride displays a polishing rate similar to ferric nitrate, while the sulfate salt polishes at a higher rate, but with somewhat poor uniformity.

AGING TESTS

Using the same procedure for making Batch C of the slurry using $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ as described above for Experiment 3, and using the same test procedure for
10 measuring defect counts (scratching), the effects of aging the slurry were measured. Two Test Wafers were run and data obtained in one-day increments over a six-day aging period. As seen from FIG. 6, the scratch count decreases dramatically over the six-day aging period. After six days aging, the decrease defect count is decreased to
15 less than 10% from the one-day defect count value.

It will be apparent to those skilled in the art having reference to this disclosure that other modifications of this invention beyond those embodiments specifically described here may be made without departing from the spirit of the invention. Accordingly, it is not our intention to restrict our invention to the embodiments
20 described but that the scope of the inventions shall be determined by the following claims. With this in view,

WHAT IS CLAIMED IS:

1. A chemical-mechanical polishing (CMP) slurry comprising:
abrasive particles, all said abrasive particles having a median particle diameter less than 0.400 microns and a standard one sigma diameter deviation of approximately 25% or less;
a ferric salt oxidizer,
and a suspension agent.
2. The CMP slurry of claim 1 including deionized water.
3. The CMP slurry of claim 2 wherein the median diameter of the abrasive particle is 0.220 microns.
4. The CMP slurry of claim 3 wherein said one sigma diameter deviation is 0.050 micro inches or less.
5. The CMP slurry of claim 4 wherein said abrasive particle is selected from a group consisting of Al_2O_3 , SiC , SiO_2 , CeO_2 or Si_3N_4 .
6. The CMP slurry of claim 5 wherein said abrasive particle is Al_2O_3 .
7. The CMP slurry of claim 1 wherein said ferric salt is selected from a group consisting of $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, $\text{Fe}_2(\text{SO}_4)_3 \cdot 5\text{H}_2\text{O}$, $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$, $\text{FeNH}_4(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$.
8. The CMP of claim 1 wherein said suspension agent is an aqueous surfactant.
9. The CMP of claim 8 wherein said aqueous surfactant is a mixture of propyleneglycol and methylparaben.

10. The CMP of claim 3 wherein the abrasive particle is in the range of 2-6 wt. percent of the total mixture.
11. The CMP of claim 3 wherein the abrasive particle is 2.8 wt. percent of the total mixture.
12. The CMP of claim 3 wherein the ferric salt is in the range of 4-9 wt. percent of the total mixture.
13. The CMP of claim 12 wherein the ferric salt is 5 wt. percent of the total mixture.
14. A method of making a chemical-mechanical polish (CMP) slurry comprising:
 - (a) coating abrasive particles in an aqueous concentrate having a median particle diameter less than 0.400 microns with a surfactant;
 - (b) then mixing water with said coated abrasive particles to form a slurry; and
 - (c) then mixing a ferric salt oxidizer into said slurry.
15. The method of claim 14 wherein said step of coating abrasive particles includes physically vigorously mixing said particles in said aqueous concentrate with said surfactant for a time on the order of one hour before addition of said water.
16. The method of claim 14 wherein said abrasive particles are Al_2O_3 .
17. The method of claim 16 wherein said abrasive particles have a median diameter of 0.220 microns and a one sigma deviation of 0.050 microns or better.
18. The method of claim 16 wherein said ferric salt is $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$.
19. The method of claim 18 wherein said abrasive particle concentrate is 20 volume %, said surfactant is 15 volume %, said water is 65 volume % and said ferric

salt is 5 wt% of the slurry.

20. The method of claim 14 wherein said slurry mixture is aged for a period of time on the order of more than one day after mixture before being used.

21. The method of claim 20 wherein said aging period of time is three days or more.

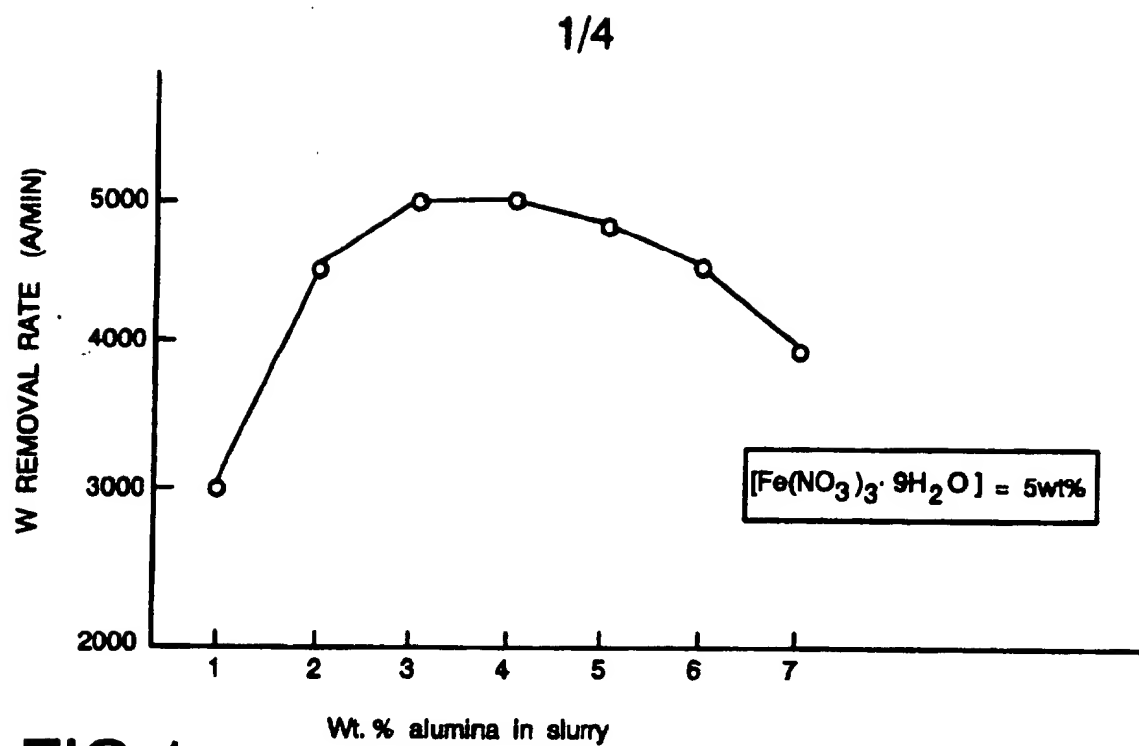


FIG. 1

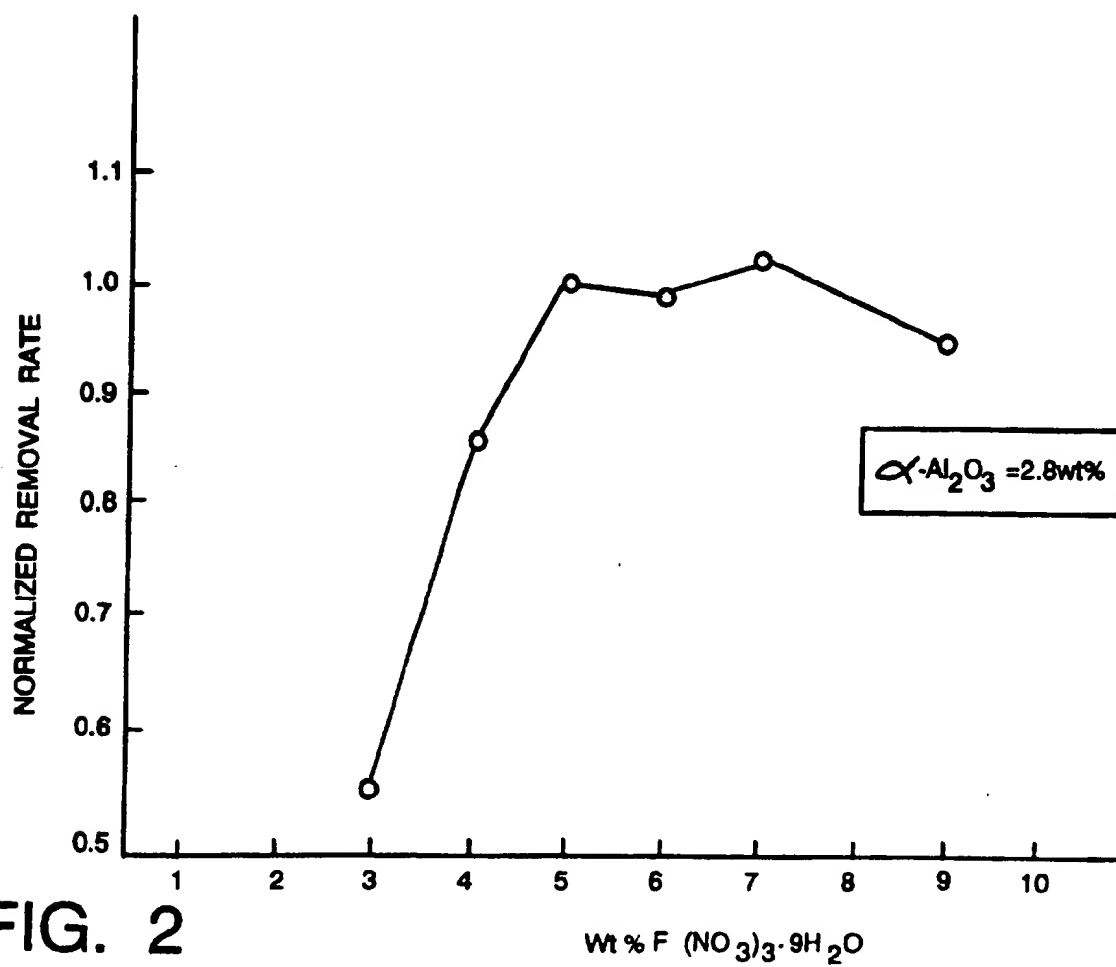


FIG. 2

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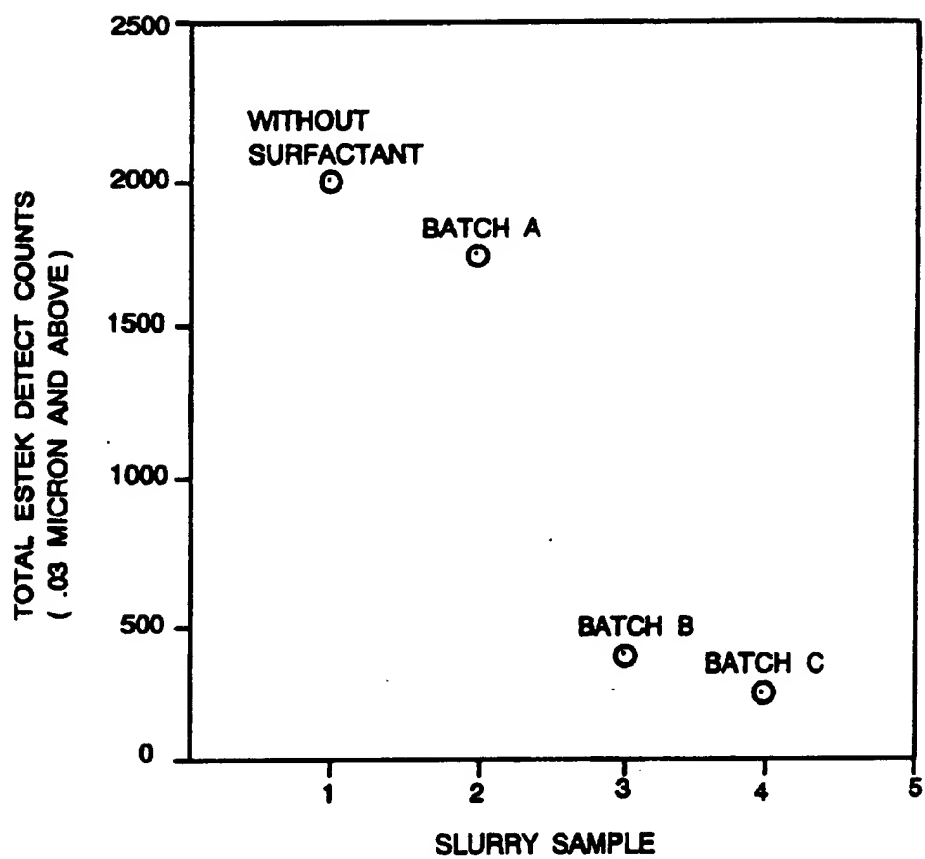


FIG. 3

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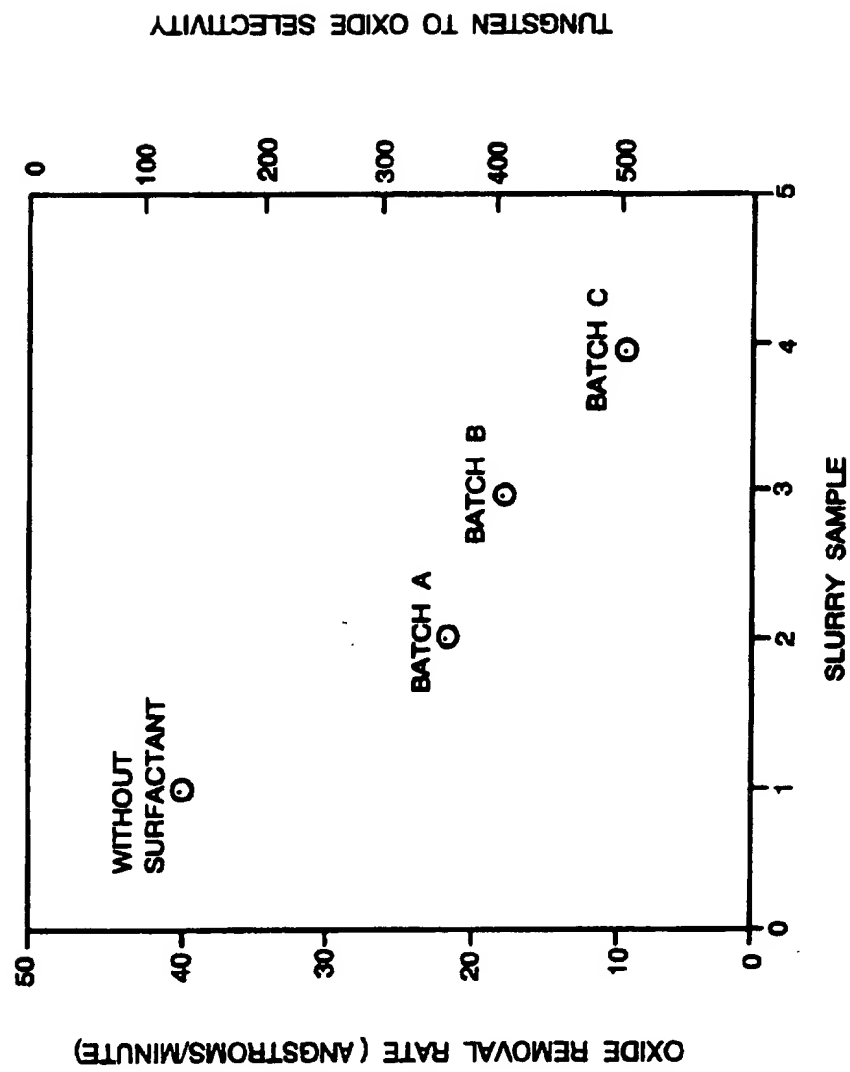


FIG. 4

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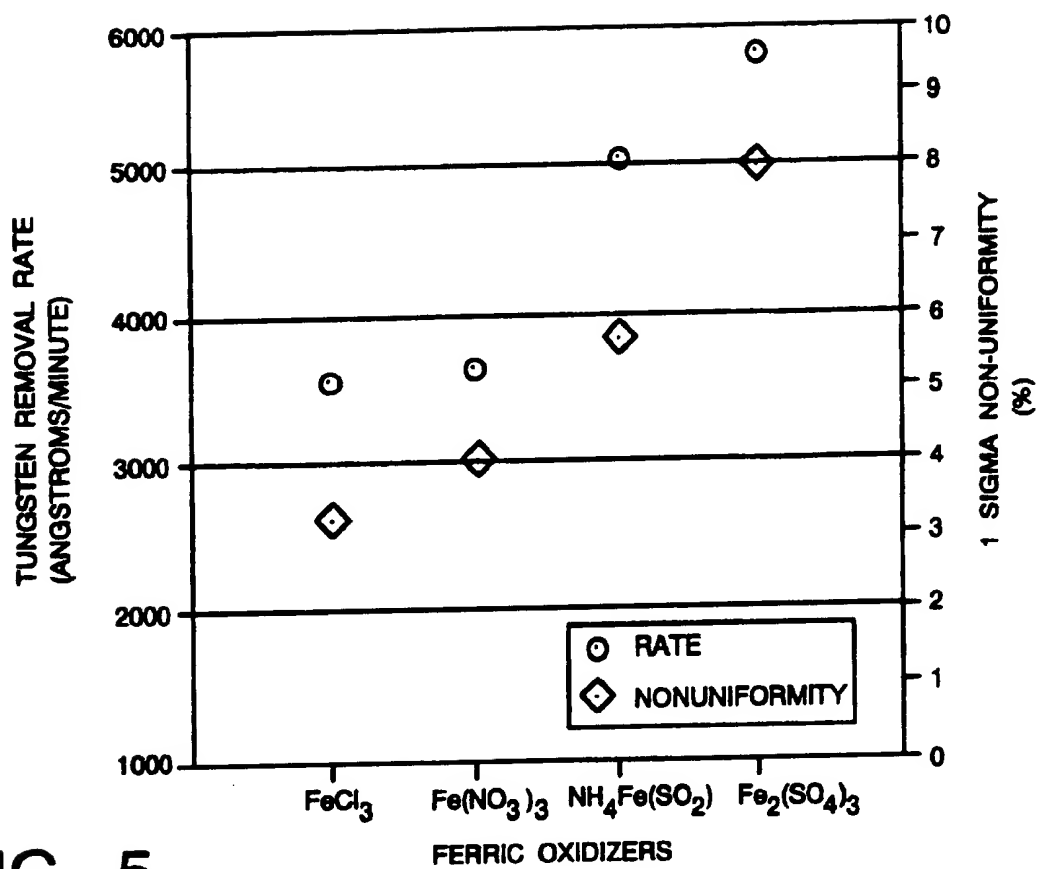


FIG. 5

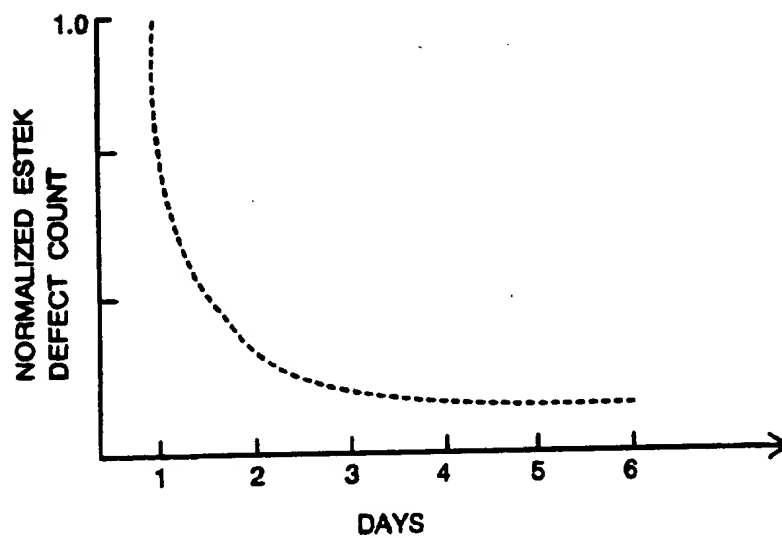


FIG. 6

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01L21/3105 H01L21/306

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	<p>ADVANCED METALLIZATION FOR DEVICES AND CIRCUITS - SCIENCE, TECHNOLOGY AND MANUFACTURABILITY SYMPOSIUM, ADVANCED METALLIZATION FOR DEVICES AND CIRCUITS - SCIENCE, TECHNOLOGY AND MANUFACTURABILITY, SAN FRANCISCO, CA, USA, 4-8 APRIL 1994, 1994, PITTSBURGH, PA, USA, MATER. RES. SOC, USA, pages 121-131, XP002000076 JAIRATH R ET AL: "Consumables for the chemical mechanical polishing (CMP) of dielectrics and conductors" page 122, section (a) "Slurries used in CMP processes"; page 124, last paragraph --- -/--</p>	1,2,5,6, 8-10, 14-16

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,3 817 727 (YANCEY P) 18 June 1974 see column 1, line 34 - line 61 example 1 ---	1,2,5,6, 8-10, 14-16
Y	JOURNAL OF THE ELECTROCHEMICAL SOCIETY, vol. 138, no. 11, 1 November 1991, pages 3460-3465, XP000248109 KAUFMAN F B: "CHEMICAL-MECHANICAL POLISHING FOR FABRICATING PATTERNED W METAL FEATURES AS CHIP INTERCONNECTS" see figure 2 page 3464, left hand column, second full paragraph; equations 1 and 2 ---	1,2,5,6, 8-10, 14-16
A	US,A,3 922 393 (SEARS JR GEORGE WALLACE) 25 November 1975 see column 1, line 24 - line 25 example 1 ---	1-5,8, 10-17,19
A	US,A,5 340 370 (CADIEN KENNETH C ET AL) 23 August 1994 see column 6, line 36 - column 7, line 20 ---	1
A	EP,A,0 561 132 (IBM) 22 September 1993 see page 6, line 51 - page 7, line 52 -----	7,18

INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/US 95/13919

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